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Indian Standard

METHOD FOR GAUGING OF PETROLEUM AND LIQUID PETROLEUM PRODUCTS

(First Revision)

UDC 665·6/·7 : 531·732·08

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INDIAN STANDARDS INSTITUTION
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METHOD FOR GAUGING OF PETROLEUM AND LIQUID PETROLEUM PRODUCTS
(First Revision)

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Indian Standard
METHOD FOR GAUGING OF PETROLEUM AND LIQUID PETROLEUM PRODUCTS
(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 15 October 1980, after the draft finalized by the Petroleum Measurements Sectional Committee had been approved by the Petroleum, Coal and Related Products Division Council.

0.2 This standard was first published in 1960. Later three amendments were issued to modify various terms given in this standard. In the present revision, the standard has been reviewed and revised in light of recent advances in the field of petroleum measurements. In this revision, various characteristics have been modified and the amendments incorporated suitably.

0.3 The accurate gauging of bulk quantities of petroleum and liquid petroleum products is essential for stock accounting, loss control, custom and excise purposes, and for blending and similar operations. Methods of measuring the quantity of the material received, stored, delievered or transferred vary with the type of product and construction of the container. The directions given in this standard lay down the procedure to be adopted for determining the volume of the material in any of the different types of containers normally employed for the bulk storage of petroleum and liquid petroleum products. Whilst no brief set of standard methods can cover all conditions and requirements which may arise in practice, the various methods and procedures described herein are intended to provide a general standard of uniformity; they shall be closely followed in order to ensure the required degree of accuracy. Every effort shall be made to ensure the safety of personnel and plant. The safety precautions given in Section IV of this standard are recommended as good practice and should be followed when they do not conflict with local safety or other regulations. These regulations, of course, shall always be strictly observed.

0.4 The specifications for some of the apparatus used in gauging of petroleum and liquid petroleum products were formulated by the Weights and Measurements Sectional Committee, EDC 41. For general guidance some of the requirements for the remaining apparatus are described in Appendix A.

0.5 Taking into consideration the views of interests concerned, the Sectional Committee responsible for the preparation of this standard felt that it should be related to the trade practices followed in the country in this field. Furthermore, due weightage had to be given to the need for international coordination among standards prevailing in different countries of the world in this field. This standard, has therefore, been developed, utilizing the standards and other publications of Institute of Petroleum (IP), London, and American Society for Testing Materials (ASTM), Philadelphia (USA).

0.6 This standard requires reference to the following Indian Standards:

IS : 1447-1966 Methods of sampling of petroleum and its products.

IS : 1519 (Part I) - 1962 Method for temperature measurement of petroleum and its products, Part I.

IS : 1519 (Part II) - 1964 Method for temperature measurement of petroleum and its products, Part II.

0.7 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

1. SCOPE

1.1 This standard prescribes methods for gauging of volume of petroleum and liquid petroleum products in tanks; ships and barges; tank cars and tank trucks; and pipe-lines (*see also* **3.1**). It also covers liquified petroleum gases.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Average Dip — The average dip of the measurement of more than one dip taken in a tank or other containers as described in Section II of this standard.

2.2 Average Water Dip — The average of the actual measurements of depth of water lying in the bottom of the tank (*see also* **2.1**, **2.14** and **2.24**).

2.3 Calibration Table — A table showing the capacities of, or volumes in a container corresponding to various liquid levels measured from the dipping datum point, or from the ullage reference point.

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*Rules for rounding off numerical values (*revised*).

2.4 Compensating Reference Point—Gas Lock Apparatus — Movable cursor against which the tape readings are taken. This cursor is so arranged that it remains at a fixed distance above the tank bottom irrespective of change of position of the gas-lock apparatus caused by the tank roof movement (*see* **14.2.1**).

2.5 Conventional Tank — A vertical cylindrical tank with a fixed roof commonly employed in the petroleum industry and which is not constructed to withstand any appreciable pressure or vacuum in the vapour space. It may, therefore, be gauged directly through an open hatch.

2.6 Datum Plate — A level metal plate attached to the tank bottom, or to the shell, directly under the dipping reference point, to provide a smooth surface for the dip weight to rest upon (*see* **2.8**).

2.7 Dip — The total depth of liquid in a container measured directly by means of the graduated dip tape and dip weight, or by a graduated rod, reaching the dipping datum point at the bottom of the container.

2.8 Dipping Datum Point — The point from which course (ring) heights and the effective levels of deadwood are measured and to which the bottom calibration is related in the preparation of a calibration (tank capacity) table. The calibration table shall, therefore, only be entered with a dip measured from the dipping datum point. In normal practice, the datum plate and the dipping datum point should correspond.

2.9 Dipping Reference Point — A point clearly marked on the dip hatch directly above the dipping datum point to indicate the position of the tape when dipping. The exact height of the dipping reference point above the datum plate shall be clearly marked on the roof of the tank near the dip-hatch.

2.10 Dip Pipe — An open ended pipe attached by a vapour-tight joint to a vapour-tight container. The pipe projects downwards, ending near the bottom of the tank, directly above the datum plate.

NOTE — The term dip pipe is also used to denote a perforated pipe sometimes fitted below the dip hatch to act as a guide for the dip weight or dip rod, particularly when obstructions have to be avoided.

2.11 Dip Point — *See* **2.8**.

2.12 Equivalent Dip — The depth of liquid in a container corresponding to a given ullage. It is obtained by subtracting the observed ullage from the height of the ullage reference point above the dipping datum point on the bottom of the container.

2.13 Floating Roof Tank — A tank in which the roof floats freely on the surface of the liquid contents except at low levels when the weight of the roof is taken on supports on the tank bottom.

2.14 Free Water — The water which has completely separated out of the material and settled down at the bottom of the tank, and which on gauging cuts or discolours the water finding paste or paper across the whole width of the water finding rule or tape in horizontal line, will be considered to be free water.

2.15 Innage — *See* **2.7**.

2.16 Manometer — A U-shaped instrument for measuring small pressure differentials. A scale graduated in millimetres and centimetres is located between the arms of the U-Tube.

2.17 Outage — The distance between the ullage reference point and the upper surface of the liquid in a container.

2.18 Pressure Type Tank — A tank specially constructed for the storage of volatile liquids under pressure. Such tanks are spheroidal, spherical, hemispherically ended or of other special shapes.

2.19 Sludge — The term used to denote a layer of sediment with or without emulsion which may be present at the lower levels in a container.

2.20 Ullage — *See* **2.17**.

2.21 Ullage Reference Point — A point clearly marked on the ullage hatch, or an attachment suitably located above or below the ullage hatch, and situated at a fixed and known distance greater than the maximum liquid depth above the bottom of a container.

2.22 Vapour Tight Tank — A tank of conventional shape intended primarily for the storage of volatile liquids, for example, gasoline, and so constructed that it will withstand pressures differing only slightly from atmosphere. Such tanks are equipped with special devices which permit gauging without opening the tanks to atmosphere.

2.23 Water Bottom — A layer of water at the bottom of a container, of such depth as to cover the bottom completely.

2.24 Water Dip — The depth of water in a container measured by any of the method described in **9**.

SECTION I GAUGING METHODS

3. GENERAL

3.1 The quantity of liquid in a container is most frequently determined by extracting from the calibration table the volume corresponding to the height of the liquid in the container. This height can be determined by the direct measurement of the dip or from the ullage, or when a container is so fitted, from the readings given by a gauge glass, gauge column or a hydrostatic gauge. These methods are described in this section.

4. DIPPING

4.1 By Dip Tape and Dip Weight — A standard dip tape and dip weight (*see* **A-1.1** and **A-1.2**) shall be used. The dip tape, which shall be greater in length than the overall height of the tank or container to be dipped, is wound in a suitable frame or case and the dip weight is attached to the swivel at the free end of the tape. The type of weight employed will depend upon the liquid being gauged. It is recommended that for oils of low viscosity, the light weight should be used and for oils of high viscosity or when there are appreciable quantities of rust or sediment on the tank bottom, the heavy weight be used. The tape shall be lowered carefully (*see* Note) through the dip hatch and shall be held against the side of hatch at the dipping reference point to prevent oscillation. Care shall be taken not to disturb the surface of the oil unduly and lowering shall be continued until the bottom of the weight just touches the datum point at the tank bottom. If the tape becomes slack or the weight is allowed to tilt, the tape shall be withdrawn until a suitable length can be wiped free from the liquid, and the operation repeated. It is desirable that the gauger checks that the graduation of the tape adjacent to the dipping reference point is in agreement with the indicated height of the reference point. If the reading does not agree, the discrepancy shall be investigated. When the height of the reference point has been compared, as above, the tape shall be withdrawn and the depth to which the tape is wetted with the liquid read to the nearest graduation. The tape shall then be wiped free from liquid down to a short distance below the reading and the operation repeated. If the second measurement does not agree with the first, further measurements shall be made until two measurements give readings agreeable within 3 mm. The average of these two readings is the oil depth, or oil plus water bottom, at the point where the dip is taken. The method is illustrated diagrammatically in Fig. 1. Measurements shall be recorded immediately together with the date and time, the tank number and the batch number or location. The temperature of the tank contents shall be measured and recorded at the time of dipping in accordance with IS : 1519 (Part I)-1961* and, in the case of vapour-tight tanks fitted with a dip pipe and manometer, the manometer reading shall also be recorded.

NOTE — When taking a dip, the lowering of the dip tape and dip weight shall be stopped when the latter is at a short distance from the tank bottom to allow time for any disturbance of the liquid to subside before the weight is allowed gently to touch the tank bottom. In the case of viscous liquids, the weight shall be maintained in contact with the tank bottom for a few seconds to allow surface of the liquid surrounding the tape to assume the correct level in order to avoid a low reading. With volatile liquids, a clear reading will usually be obtained if the tape is first wiped dry. Gasoline level indicating paste (ullage paste) smeared on the tape in the vicinity of the expected reading may be used in cases of difficulty. *Chalk or other porous material shall not be used to facilitate reading.*

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*Method for temperature measurement of petroleum and its products, Part I.

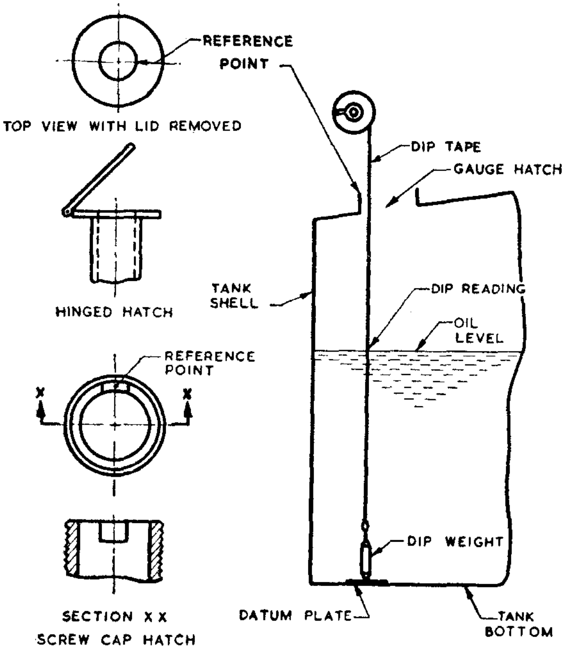

FIG. 1 DIPPING BY DIP TAPE AND DIP WEIGHT

4.2 By Dip Rod — Small conventional tanks or other containers may be dipped by the method described in **4.1** or, alternatively, by means of straight, rigid dip rod (*see* **A-1.3**) constructed of brass or other non-sparking metal. The dip rod may be graduated either (a) in units of length or (b) in units of volume or capacity. For (b), the rod shall be calibrated for the particular tank or tanks with which it is to be used, and shall bear the same identification mark or marks, and shall not be used for any other tank or tanks. When such a dip rod is applicable to more than one tank, these tanks shall be identical in size, shape and other relevant particulars. When dipping by this method, the rod shall be lowered vertically from the reference point and probed against the tank bottom to ensure that the lower end of the rod is resting on the datum point at the tank bottom. With the rod in this position, the reading on the rod horizontally in line with the reference point shall be noted. The rod shall then be withdrawn sufficiently to allow oil to be wiped from the neighbourhood of the reading. The rod shall again be lowered. There shall be a pause in lowering the rod just before it touches the tank bottom to allow time for any disturbance of the liquid to subside, this being of particular importance where a dip pipe is fitted. The rod shall then be gently lowered to contact the tank bottom. Finally, it shall be withdrawn and the dip reading noted. This procedure shall be repeated until two readings agreeing within 3 mm are obtained. Measurements shall be recorded immediately as in **4.1**. The average of the two readings is the oil depth or oil plus water bottom in the tank.

NOTE — While determining the oil and water dips, the water dip should be taken first followed by oil dip.

5. ULLAGING

5.1 By Dip Tape and Ullage Rule — In this method, the standard dip tape (*see* **A-1.1**) and ullage rule (*see* **A-1.4**) shall be used. The ullage rule attached to the swivel of the dip tape shall be lowered through the dip hatch as shown diagrammatically in Fig. 2, the tape being held against the side of the hatch and adjacent to the ullage reference point. When the ullage rule is near the surface of the liquid, it should be lowered slowly to avoid causing splashes or ripples, until the bottom of the rule enters the surface of the liquid. The rule shall be held at this level until any disturbance on the liquid surface has subsided. Lowering shall then be continued slowly until a convenient reading on the tape is precisely in line with the ullage reference point. The rule shall then be withdrawn and the length of the graduated part of the rule, which has not been wetted by the liquid, read off. The sum of the reading on the tape opposite the reference point on the reading on the ullage rule so obtained is the required ullage. The procedure shall be repeated until two measurements agreeing with

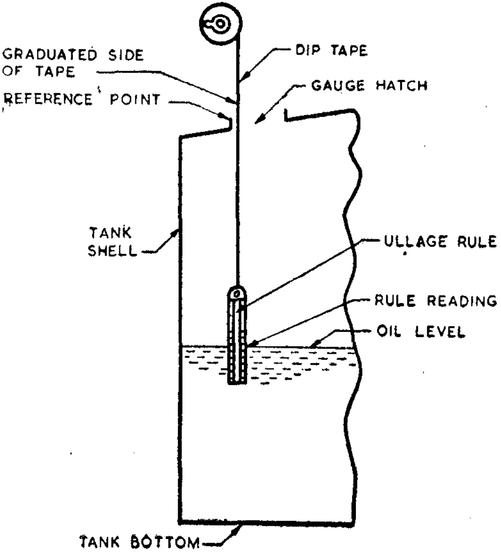

FIG. 2 ULLAGING BY DIP TAPE AND ULLAGE RULE

within 3 mm are obtained. The average reading and the other relevant details, such as date, time, tank and hatch number and oil temperature, shall be recorded as in **4.1**.

NOTE — It is recommended that when the ullage is being measured, the tape reading which is set in line with the ullage reference point should be the largest whole major unit possible. By this method, the possibility of error in adding the two measurements is reduced.

5.2 By Dip Tape and Dip Weight — The following alternative method for measuring ullage shall be used only when an ullage rule is not available. The method gives accurate results but, since it involves taking the difference between two measurements and not their sum, it is more liable to error than the ullage-rule method. The procedure is similar to that described in **5.1**, but the ullage rule is replaced by a standard dip weight. The ullage shall be obtained by lowering the weight from the ullage preference point until it is completely immersed in the liquid to a depth of about 10 cm, care being taken to lower the weight slowly just before it touches the liquid surface. The weight shall be held in this position until any disturbance of the liquid surface has subsided. Lowering shall then be continued slowly until the next whole metre marked on the tape is precisely in line with the ullage reference point. The tape shall then be withdrawn and both the length of tape, which has been wetted with liquid, and the graduation, which was in line with the ullage reference point, shall be noted. The difference between these two measurements is the ullage.

5.2.1 It is frequently convenient, and in certain cases necessary, to convert ullage measurements to equivalent dip, and this can be done by substracting the ullage from the height of the reference point above the datum point at the tank bottom. The equivalent dip may be obtained more directly by using a dip tape and dip weight. The height of the ullage reference point shall first be noted and the dip weight then lowered below the surface of the liquid until the graduation on the tape in line with the reference point contains the same number of odd centimetres and fractions thereof as occur in the reference height. The tape shall then be withdrawn and the measurements noted in the usual way. The difference between the tape reading at the reference point and the marked reference height will be a whole number of centimetres and can be quickly determined. The sum of this difference and the reading of the wetted length of tape is then the equivalent dip. The procedure is illustrated by the following example:

Height from the datum point on the bottom to the reference point	1 136·4 cm
Less : Tape reading at the reference point	636·4 cm
Difference	500·0 cm
Plus : Wetted length of tape	87·9 cm
Equivalent dip	587·9 cm

5.3 By Ullage Stick — Small containers, for example, rail-cars, which are filled to a level just below the ullage reference point, may be ullaged by an ullage stick (ullage rod) (*see* **A-1.5**). This apparatus shall not be employed in larger containers and shall not replace the ullage rule and tape when these are available. Before an ullage stick is used, the position, relative to the zero graduation, of the underside of the cross-piece shall be visually checked, and if the cross-piece is found to be displaced, the ullage stick shall be discarded and another employed. The ullage shall be measured by suspending the ullage stick vertically from the cross-piece and lowering it slowely into the liquid in the container until the cross-piece comes to rest horizontally across the top of the hatch or tank opening. Care shall be taken not to disturb the liquid surface. The stick shall then be withdrawn and the length of stick, which has not been wetted, read directly on the graduated scale. This procedure shall be repeated until two measurements give readings not differing by more than 3 mm from each other. The average of the two readings shall be taken as the final measurement. If the container has a fixed reference point which does not coincide with the underside of the cross-piece when the ullage stick is resting across the top of the hatch, a correction shall be made to the observed reading for the distance between the top of the hatch and the reference point.

6. GAUGE GLASS READING

6.1 Gauge glasses (*see* Fig. 3) shall be arranged in an overlapping vertical series up the side of the container as specified in **6.2.** Before a reading can be obtained, it is necessary to determine in which gauge glass the liquid level of the container will be indicated. This may be already known; but if not, each glass shall be examined in turn. In order to avoid unnecessary waste and to reduce possible operational hazards, it is recommended that the glasses be examined in the order from the uppermost downwards. The cocks connecting the container to each gauge glass examined shall first be closed and the contents of the glass, if any, drained off. This may involve a temporary opening of the top connection to allow the liquid to flow from the glass. The drain shall then be closed and the connections to the container opened. If the liquid level of the container is within the vertical distance covered by the gauge glass, liquid will be seen to flow into the glass from the bottom. If liquid is not present, the lower glasses shall be examined in turn until the appropriate gauge glass is found.

6.1.1 Before reading the liquid level, the gauge glass shall be drained and then flushed through. This shall be done by opening both the cocks (or valves), first the upper one and then the lower, to allow liquid from the container to flow freely into it. The bottom cock shall then be closed to the container and the glass emptied by opening the drain. The glass shall be flushed through and drained not less than three times. The number of flushings and the time for which the liquid remains in the glass before emptying

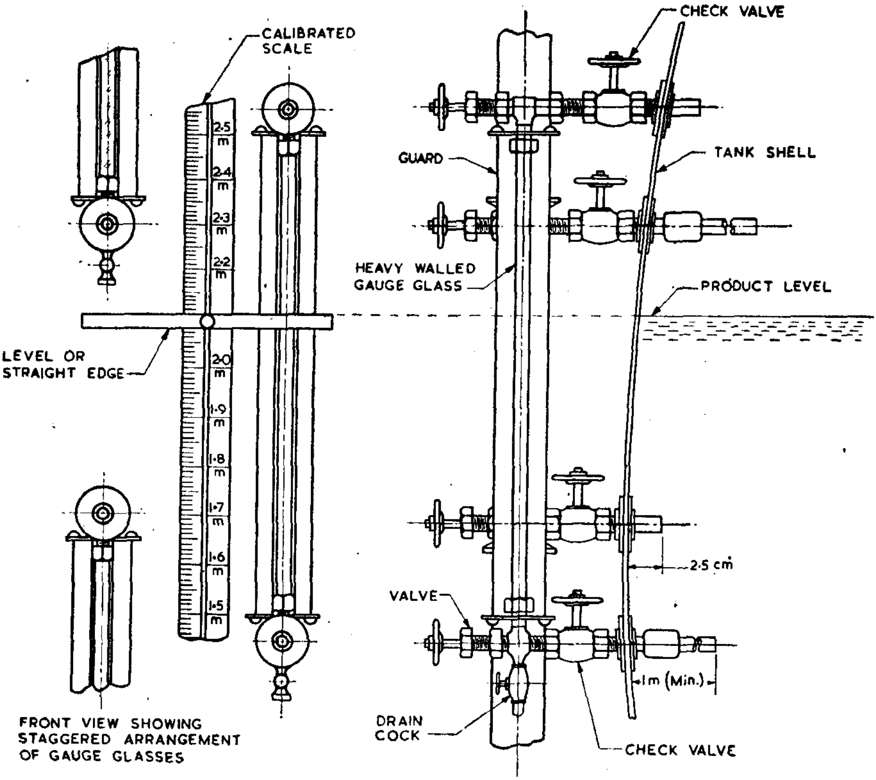

FIG. 3 TYPICAL ARRANGEMENT OF STAGGERED GAUGE GLASSES

shall be such that, when the liquid depth is read, the liquid in the glass is at substantially the same temperature and, therefore, has the same density as the liquid in the tank at the level of entry into the glass. If there is any doubt on this point, flushing, draining and measurement of the liquid depth shall be repeated until the measured depth is constant. As soon as flushing is completed, the gauge glass shall again be filled with liquid from the tank and as soon as surging has ceased, the liquid depth shall be read with the connections at both ends of the gauge glass open to the tank. The reading shall be taken by holding a straight-edged ruler horizontally across the bottom of the oil meniscus and reading the corresponding graduation on the scale attached to the gauge glass. Alternatively, if the scale is so fitted, the reading may be taken with the aid of a sliding T-piece. If water is present in the container above the lower connection to the gauge glass, the oil gauge cannot be determined. In order to measure the oil quantity in such cases, it is necessary to drain off water from the container until the water level is below the bottom connection to the gauge glass in which the oil is found.

6.2 Gauge glasses used for measuring the liquid content of containers shall be installed alongside a stairway on the side of the tank least affected by the weather, and shall cover a continuous range from 30 cm below the lowest point of the tank to 30 cm above the maximum capacity level. The glasses shall be of the conventional glass tube type or of the safety type consisting of thick glass plates suitably clamped in a metal housing. It is recommended that the latter type be used for liquids stored under conditions of high pressure; the former type shall always be fitted with guards.

6.2.1 Gauge glasses shall be installed with the following specifications:

a) *Construction* — Each glass shall have a maximum length of one metre and shall be connected by a packed gland or other suitable means to top and bottom mountings incorporating an excess flow valve and equipped with quick acting valves. The bottom mounting shall also be fitted with a drain cock (*see also* **14.2.1**);

b) *Arrangement* — The glasses shall be arranged vertically and alternately in two adjacent columns. Each glass shall be connected directly to the container and adjacent glasses shall overlap by not less than 5 cm;

c) *Gauge connections* — The top and bottom mountings of each gauge glass shall be connected to the container by means of a corrosion-resistant metal pipe of not less than 13 mm internal diameter. The lower pipe shall extend horizontally into the container for a distance of 1 metre to 2 metres; and the upper pipe for a distance of not less than 2·5 cm; and

d) *Scale* — Gauge scales shall be installed closely alongside and parallel to each individual glass, and shall be securely adjusted so as to give continuous reading from a common zero. The scales shall be graduated in metres, centimetres and millimetres upwards from a zero point, which shall correspond with a datum marked on a rigid structural member of the container. All graduation lines and figures for each metre and each 10 cm shall be marked clearly and permanently on the scale. If desired, the scale may, alternatively, be graduated directly in units of volume.

NOTE — It is appreciated that some existing tankage may not be equipped in accordance with the recommended standards. If such a tank, fitted with only one (long) gauge glass, contains water, it is obviously necessary to drain off all the water before taking a gauge glass reading.

7. MEASUREMENT BY GAUGE COLUMN

7.1 Where a gauge column (*see* Fig. 4) is installed for measuring the contents of a tank or of a number of tanks, official reading shall be taken only after the liquid from the tank to be measured has been circulated through

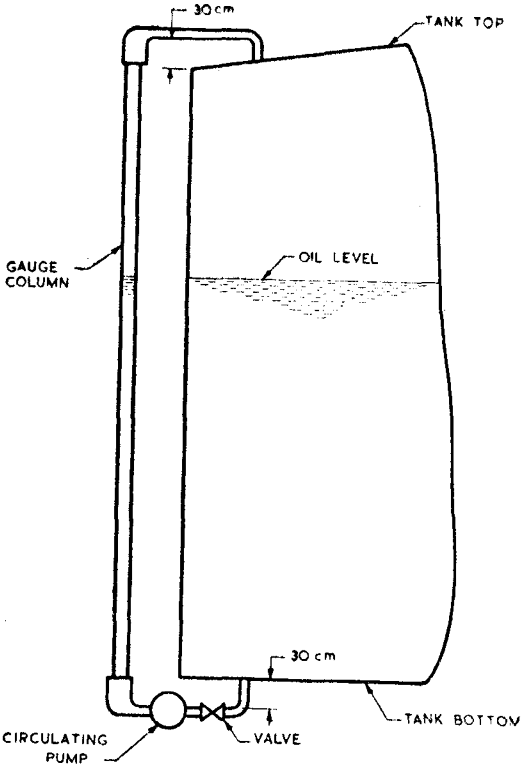

FIG. 4 GAUGE COLUMN

the column for an adequate period. To measure the liquid depth in a container, the upper and lower ends of the column shall be connected to the vapour and liquid space, respectively, of the tank to be measured. By means of the pump arranged in the lower line connecting the column to the tank, liquid from the tank shall be delivered through the lower gauge connection and returned to the tank via the upper connection. There will thus be a continuous upward flow of liquid through the column. The thermometers provided in the column shall be read at intervals and when the mean of the temperatures recorded by these thermometers is within 0·5°C of the mean temperature of the tank as determined by the method laid down in IS : 1519 (Part I)-1961* circulation shall be stopped. The by-pass valve fitted to the pump shall then be opened so that the tank and the column are in free communication via both the upper and the lower connections. As soon as any surging in the column has stopped, the liquid height shall be read on the scale adjacent to the sighting-glasses. The height shall be recorded together with the temperatures shown by the thermometers fitted to the column. The mean temperature of the tank shall be separately measured and recorded. Samples for specific gravity or density determination but not for temperature may conveniently be drawn from the circuit just before circulation is stopped.

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*Method for temperature measurement of petroleum and its products, Part I.

8. HYDROSTATIC GAUGES

8.1 A hydrostatic gauge measures the hydrostatic pressure resulting from the head of liquid in the container to which it is fitted. The hydrostatic pressure is a function of the density of the liquid and its depth. The gauge may, therefore, be calibrated to give the quantity of liquid in the container in terms of weight, volume or liquid depth. Due allowance for the shape and size of the container and the height of the gauge datum above the bottom of the container shall be made on the initial calibration. The gauge shall also be calibrated for a pre-determined liquid density (a) in all cases when it is calibrated in units of volume or liquid depth and (b) when it is fitted to a tank of varying horizontal cross section and is calibrated in units of weight. If a gauge is calibrated for a fixed liquid density, this density shall be clearly indicated on the instrument, and if it is used when the liquid in the container is of a different density, a correction to the observed readings of the gauge shall be made. The appropriate correction shall be obtained from calibration data which shall be supplied with the gauge. When a gauge calibrated in units of weight is fitted to a container of constant horizontal cross section, the readings will be independent of density, and hence temperature, of the liquid in the container. When the container is not freely vented to atmosphere, the pressure in the vapour space above the liquid affects the gauge reading and compensation shall be provided by means of connection from the vapour space to the size of the gauge opposite that to which the liquid pressure line is connected.

If any water is present in the container, this shall be measured by independent means. Careful allowance shall be made for this in calculating the quantity of oil in the container. Any water necessarily present shall be maintained at a level below datum at which the connection to the hydrostatic gauge is installed. Hydrostatic gauges may be arranged for direct connection to a container, when the hydrostatic pressure is communicated to the guage by the liquid being measured. Alternatively, a compressed air system my be employed when the gauge may be arranged for remote reading. The recording portion of the gauge in each case may be either (a) a manometer filled with mercury or some other suitable liquid or (b) a pointer and dial indicator operated by a suitably designed pressure capsule or Bourdon tube. Measurements obtained by means of hydrostatic gauges may be subject to the number of errors and such gauges can only be recommended for official purposes when they are carefully constructed and calibrated, correctly installed and maintained in good condition. Where high accuracy is not essential, they have advantages in gauging tanks which are not readily accessible.

9. MEASUREMENT OF WATER

9.1 By Water-Finding Rule and Paste or Paper — The standard water-finding rule specified in **A-1.6** shall be used if the water depth does not exceed 25 cm. The rule attached to a standard dip tape shall be coated very thinly with water-finding paste, or shall have one or more strips of water-finding paper attached to it vertically by means of the clips. With the tape held against the side of the dip hatch and adjacent to the dipping reference point, the rule shall be lowered into the container until it lightly touches the datum point at the bottom (*see* Fig. 5). In order to ensure that the rule is not resting on an obstruction on the bottom, the height of the dipping reference point shall be checked against tape reading. An allowance of 15 cm shall be made for the difference in length between the standard water-finding rule and the standard dip weight. If a check cannot be obtained, a procedure similar to that outlined in **4.1** shall be followed. The tape shall be kept taut to ensure that the rule remains vertical, in which position it shall be maintained for a sufficient length of time for the water to remove the paste or change its colour, or, where paper is used,

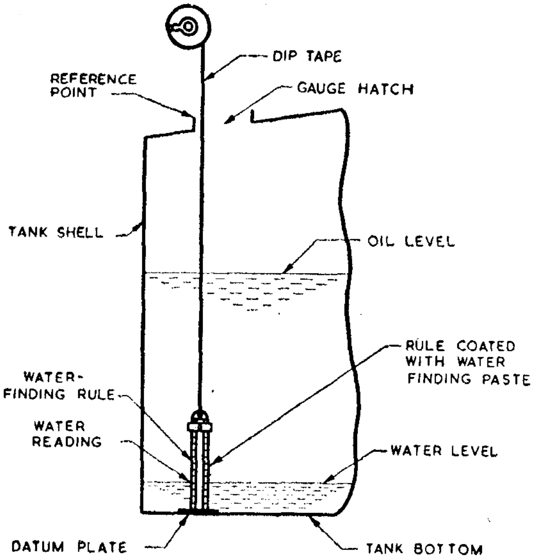

FIG. 5 WATER MEASUREMENT BY DIP TAPE AND WATER-FINDING RULE

to change the colour of the paper. The rule shall then be withdrawn and the upper limit of the water mark measured and recorded. In general, when using paste, five to ten seconds immersion time is sufficient for gasoline and kerosine, and from thirty to sixty seconds for heavier oils. For paper, longer periods are required, depending upon the oil product lying above the water surface. If a clear water reading is not obtained during the first immersion of the rule, any affected paste or paper shall be removed and a fresh application made before a further reading is taken. When measuring water depths in black liquid, it may be necessary to wash the liquid from the surface of the water-finding agent (paste or paper) with a solvent before the reading can be observed. A suitable solvent which will not affect the water-finding agent shall be used for this purpose and shall be employed in such a manner that the water reading is not altered. It is often difficult to obtain a reliable reading with water-finding paste when it is used in heated black liquid as the film tends to soften and run under these conditions. Water-finding paper is, however, satisfactory. Where long immersion periods are necessary to obtain satisfactory readings, or where simultaneous measurements are required at different dip hatches, the use of a dip tape with the water-finding rule may not be convenient. Provided that the water level does not exceed 25 cm, a cord may be used in place of the dip tape, but the operator shall satisfy himself that the water-finding rule is in contact with the bottom of the container and does not foul any obstruction.

9.2 By Dip Tape and Dip Weight, and Paste or Paper — The standard water-finding rule cannot be used if the depth of water to be measured is greater than its length. In such cases, the rule shall be replaced by a standard dip weight, and the water-finding paste or paper shall be applied or fixed to the tape (*see* Fig. 6). If paper is used, precautions shall be taken to ensure that the position of the paper does not change during the measuring operations. This shall be done by marking points on the paper in relation to the tape scale. The procedure for using the dip tape and weight shall be the same as when the water-finding rule is used, and the same precautions shall be observed.

9.3 By Dip Rod and Paste or Paper — The portion of the dip rod in the vicinity of the anticipated water level shall either be thinly coated with water-finding paste or have a strip of water-finding paper firmly affixed to it. The rod shall be lowered vertically into the container at the dipping reference point and pressed gently but firmly against the datum point at the bottom of the container. It shall be held in this position long enough for the water to affect the paste or paper. The rod shall then be withdrawn and the reading taken in the normal way.

9.4 By Gauge Glass — The measurement of water level by means of gauge glasses is only possible when the water level in the container is higher than the lowest graduation on the gauge-glass scale and the oil level is lower

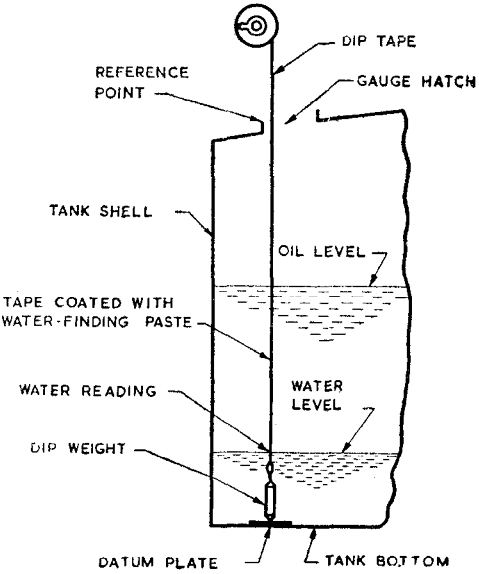

FIG. 6 WATER MEASUREMENT BY DIP TAPE AND WATER-FINDING PASTE

than the upper connection to the gauge glass, that is, when the gauge glass straddles the oil/water interface. The gauge glass shall first be drained and then flushed through two or three times. The drain cock shall then be closed and the top and bottom connections to the gauge opened. When the water level in the glass has become steady and there is no air or vapour in the upper portion of the glass, a reading shall be taken by placing a straightedged ruler, or the sliding T-piece, if fitted, horizontally across the bottom of the water meniscus and reading the corresponding graduation on the adjoining scale. The procedure shall be repeated until two consecutive measurements give the same reading. Gauge glasses are not usually provided with a vent at top, and it is often difficult to ensure that air or vapour is not trapped in the glass. To overcome this difficulty, it is recommended that, after flushing, the gauge glass be first filled with the liquid by opening the upper connection with the lower connection closed. By opening the drain, it is then usually possible to allow the liquid to flow downwards through the glass, displacing the air or vapour. The drain is then closed and the lower connection opened quickly, allowing an upward surge of water which will displace any remaining air or vapour from the top of the glass through the upper connection to the container which is left open. It may be necessary to repeat this process before all air or vapour is displaced and the correct level can be measured after the two liquids in the glass have reached equilibrium.

SECTION II GAUGING PROCEDURES

10. GENERAL

10.1 Due attention shall be paid at all times to the safety precautions given in Section IV.

10.2 While it is impossible to lay down procedures which will cover all operational and individual requirements, the following general precautions are recommended when gauging floating-roof tanks (*see* **12**):

a) Water shall be drained from the roof before gauging;

b) In the absence of a dip-pipe, a floating cover or static dissipating additive, gauging of clean refined volatile products with a metal dip or ullage rod shall not be carried out for at least 5 minutes after pumping has stopped. If there is any chance of the product being contaminated with water this period shall be extended to not less than 30 minutes.

c) The partly immersed position of the roof shall be avoided by pumping water (if this is permitted) or product into or withdrawing it from the tank until the roof is either liquid-borne, or it is at rest on its supports. When the roof is partly immersed, its actual displacement will be uncertain and again it will be difficult to gauge the tank accurately.

d) If it is suspected that the roof is prevented from being oil-borne or is held below its nomal level of floatation by friction of the shoes, then water (if this is permitted) or product shall be pumped into the tank, or product withdrawn from the tank, until the roof as a whole moves upwards or downwards. Where product is used, it will be necessary to measure and allow for the quantities so added or removed, the measurement being effected in the tank to which or from which the product is pumped. This condition may often be checked by observing whether the roof seal is parallel with the horizontal seams of the tank shell, or by taking ullages from more than one dip hatch if the roof is so fitted; and

e) For purposes other than stock accounting, the displacement of the roof can be neglected provided that floatation conditions are the same before and after a liquid movement. Conditions shall be duplicated, therefore, as closely as possible, before and after a liquid movement.

11. CONVENTIONAL SHORE TANKS

11.1 Conventional shore tanks are normally vertical or horizontal cylinders which are designed to permit gauging via an open hatch.

11.1.1 *Vertical Tanks* — The liquid in a vertical tank may be measured by the dipping or ullaging methods described in **4** or **5**, but a dip rod or ullage stick shall not be used for large tanks. Alternatively, if the tank is so fitted, gauge glasses, a gauge column or a hydrostatic gauge may be used. The choice of gauging method will be influenced by the apparatus available, local custom, the nature of the liquid being measured and other considerations. If the tank being gauged is large and is free from bottom obstruction or sediment, it is recommended that the dipping method be used for accurate measurement, as alternative methods may suffer from slight errors for which it is difficult to make adequate correction. The ullaging method, however, is recommended for tanks containing sediment or other bottom obstructions, and this method will also be found more convenient when measuring very viscous oils or bitumens at high temperatures. When liquid depths, water dips, etc, are measured in vertical shore tanks for the purpose of calculating the corresponding volume of liquid, serious errors may arise if due allowance is not made for irregularities in the tank bottom and possible movement is of the bottom plates. These errors can be eliminated by the use of water bottom. However this practice is not recommended where it affects the quality of the product or causes corrosion of the tank bottom. If water bottoms are not present, and due allowance has not been made in the tank calibration table for bottom irregularities, it is recommended that when accurate measurements are required, the bottoms of the tanks involved in movements of liquid in bulk be completely covered with the liquid, both before and after the movement takes place.

The inclusion in tank calibration tables of a fixed allowance for bottom irregularities will not compensate for additional errors which may arise when the bottom plates move as a result of variations of the liquid head, or of changes in the condition of sub-soil. Such tanks should not be measured by ullaging or by gauge glass readings. Errors resulting from bottom movements can frequently be reduced by taking dip readings at more than one dip hatch when tanks are so fitted. The method of calculating the necessary correction, when bottom movement occurs, should be the recommended standard (*see* **10.2** of IS : 2164-1961*).

11.1.2 *Horizontal Cylindrical Tanks* — The liquid may be measured by any of the methods laid down in **4** to **7**, according to available equipment, local custom or other circumstances. The dip rod, however, shall not be used in a tank of large diameter, and the ullage stick shall be used only when the liquid level is within a short distance from the ullage reference point. When a horizontal tank is installed with its major axis inclined and it is fitted with more than one dip hatch, care shall be taken to ensure that liquid shell and water depths are measured only through the dip hatch specified in the tank-calibration table. It is recommended that the calibration table be related to the lowest dip hatch. Horizontal tanks seldom contain water, but if water is present at a level below the dipping datum point, the water shall be completely drained from the tank; or water shall be added until the level shows at the dip point, before the final measurements are taken.

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*Method for calculation of bulk quantities of petroleum and liquid petroleum products.

12. FLOATING ROOF TANKS

12.1 A floating roof is designed to float on the surface of the liquid in a tank at normal operating levels. Details of design vary considerably but in general the roof extends to within a short distance from the tank shell and is kept in a central position by spring-loaded shoes (or any other method), which bear against the shell and allow the roof to move up and down with change of liquid level. Loss of vapour from the liquid in the annular space, between the roof and shell is prevented by a suitable seal of which the shoes apart. The roof is fitted with one or more dip pipes extending down to below the underside of the roof above the normal plane of floatation.

12.2 There are three positions that the roof can occupy, fully floating partially supported and partially floating and supported on the tank bottom by means of the adjustable legs fitted to the roof. For the purpose of gauging, the roof may be considered in one of the following conditions:

a) *Oil-Borne* — The roof is fully floating and the displacement is due to the total weight of the roof;

b) *Roof Supported but Partly Immersed* — In this condition, the oil level is intermediate between the level at which the oil first touches the roof and the level at which it is fully floating. In this case, the displacement is proportional to immersed roof weight; and

c) *Roof Supported but not Immersed* — In this position, the displacement is due to roof legs, roof drain line, etc, which remain immersed in oil. This is always considered as fixed bottom deadwood when working out tank-calibration tables.

12.2.1 When the roof is fully at rest on its supports, the liquid can be accurately gauged with ease, since with the roof in this position the tank may be considered as a conventional container.

12.2.2 Unless the roof is at rest on its supports, it is necessary to know the roof displacement as accurately as possible. This can be estimated from the height of the liquid level in the dip pipe relative to both the datrum point on the tank bottom and a reference point on the dip hatch, usually the edge of the hatch. The gauger, therefore, shall always report both the overall liquid dip and the ullage measured from the reference point on the dip hatch. In this case reference may be made to **19.3** of IS : 2007-1974* and **10.1.4** of IS : 2008-1961†.

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*Method for calibration of vertical oil storage tanks (*first revision*).

†Method for computing of capacity tables for vertical oil storage tanks.

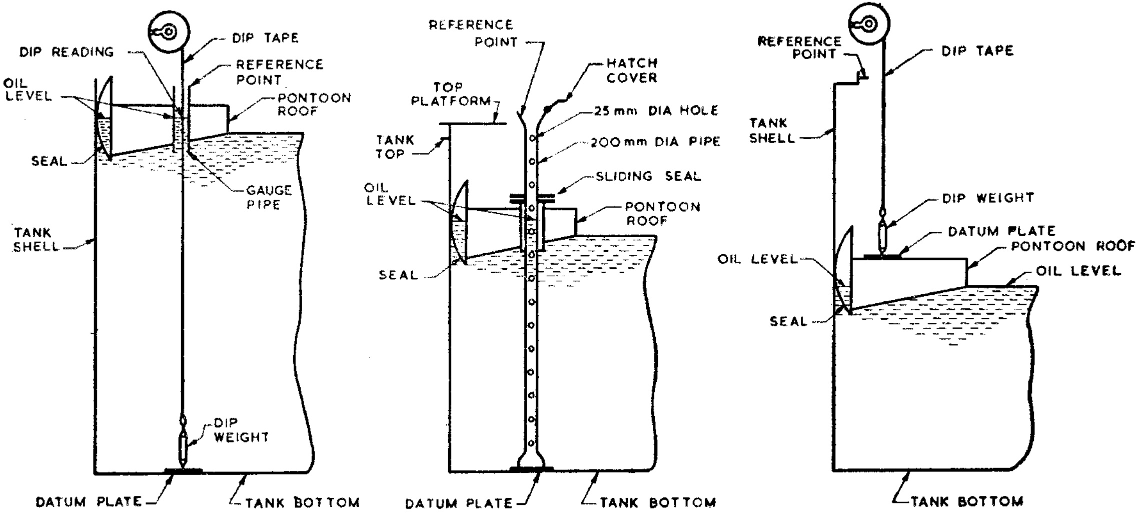
12.2.2.1 The roof displacement which is always included in the oil dip of floating roof tanks, either by innage or outage method, should be compensated for while calculating the volumes from the calibration table. The following relationship may be used:

$$\text{Roof displacement in litres at tank temperature} = \frac{\text{Weight of roof in kg}}{\text{Density of oil at tank temperature in kg/litre}}$$

12.3 When it is safe to descend on to the roof, special attention is drawn to the safety precautions given in Section IV for the purpose of gauging, or when the gauger is properly equipped with breathing apparatus, the liquid dip shall be measured from the roof in accordance with the methods laid down in **4.1** and as shown diagrammatically in Fig. 7A. When the descent to the roof is hazardous and safety apparatus is not available, the tank shall be gauged from the top platform. To enable this to be done, a second reference point consisting of a rigid arm shall be fitted at a convenient height to the top platform, extending over the dip hatch on the roof below. In addition, it shall be possible, to open the dip hatch from the platform by a suitable cord or other means. The height of the reference point on the top platform above the datum point at the tank bottom shall be accurately determined and shall be legibly marked on a convenient, nearby position. The overall height of the top reference point above the datum on the tank bottom, less the sum of the recorded oil dip and the distance between the two reference points is then the required ullage.

12.4 The floating-roof tanks can be gauged from the top platform with help of a dipping and sampling device. This allows the use of equipment required for the conventional shore tanks irrespective of the height of the roof. Basically, the device consists of a 200 mm diameter pipe arranged vertically in the tank fixed at the top and bottom above the datum plate and extending through the floating roof (*see* Fig. 7B). A sliding seal which allows for up and down and side to movement of the roof is fitted to the roof where the pipe goes through it. The pipe is fitted with a simple hatch over at the top. To ensure that the liquid contained in the dip pipe is representative of the liquid in the tank, the pipe has 25 mm diameter holes drilled at 30 cm centres along its length. The height of the reference point on the dip hatch (usually the edge of the hatch) above the datum plate at the tank bottom shall be accurately determined and shall be legibly marked on a convenient, nearby position. The liquid level in a floating-roof tank shall be measured through this dip pipe by the same method as for vertical tanks. The height of the liquid in the dip pipe will be somewhat above that of liquid in the rest of the tank due to roof displacement and accounted for in the tank calibration tables.

12.5 Another method of gauging a floating-roof tank from the top platform is to measure the distance from a fixed reference point attached to the platform to a datum plate fixed to the top of the floating roof, and gauging



7A Gauging from Roof

7B Gauging from Top Platform

7C Alternative Method for Gauging from Top Platform

FIG. 7 DIPPING OF FLOATING-ROOF TANK

through a conveniently located hatch (*see* Fig. 7C). The distance of the datum plate above the liquid level can be calculated from the roof weight and the density of the product contained in the tank. Thus, if the distance of the fixed reference point from the dipping datum point, to which the calibration table is related, is known, the gross oil dip can be determined as follows:

Gross oil dip = Overall height of reference point above dipping datum point on tank bottom *minus* (the height of the reference point above the datum plate on the tank roof *plus* the weight of the datum plate above oil level).

For day-to-day withdrawals, a calibration table giving quantities against the measured height of the reference point above the plate fixed to the roof may be used. This will not be absolutely accurate as changes in the density of the liquid will not be accounted for.

NOTE — This method of gauging can be used only with a roof in a fully floating condition, and when water dips are not required.

12.6 Water dips shall be measured in the usual way either from the top platform or from the roof according to circumstances.

13. VAPOUR-TIGHT SHORE TANKS

13.1 Vapour-tight shore tanks are usually gauged with the aid of special apparatus which will permit measurements being taken without opening the tank to atmosphere with consequent loss of vapour. The following equipment and methods are used.

13.1.1 *Gas-Lock Apparatus* — This apparatus is described in IS : 1447-1966*. It is fitted with a graduated dip tape and weight which the tank is gauged. The valve fitted to the apparatus shall first be closed and any pressure in the apparatus released to atmosphere by the petcock provided. The vapour tight door shall then be opened, the dip weight fastened to the tape and the windows, fitted to the apparatus, cleaned. The vapour-tight door shall then be securely fastened, the valve opened slowly and the tape lowered by the winding gear. When the dip has been taken in the usual way, the tape shall be rewound and the oil level on the tape read through the window in the apparatus. Considerable care is needed in taking a dip reading with this apparatus as it is less sensitive to the touch than the normal dip tape and dip weight. When very volatile liquids are being gauged, the tape may be more easily read by first applying gasoline-indicating paste to it at the appropriate level. This may be done with the applicator usually fitted to the apparatus. Water dips shall be taken similarly using either of the methods outlined in **9.1** and **9.2**. When the gauging is completed, the tape and weight shall be wound up above the valve which shall then be securely closed.

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*Methods of sampling of petroleum and its products.

13.1.2 *Gauge Glasses or Gauge Column* — The method described in **6** or **7** shall be used. Both of these methods give accurate measurement provided that the relevant apparatus is perfectly liquid- and vapour-tight and that it is correctly installed and calibrated.

13.1.3 *Dip Pipe* — A vapour-tight tank is sometimes fitted with a dip pipe extending down to within a short distance of the tank bottom and attached to the roof so that it is free to move up and down with the roof flexure. The dip pipe is open to atmosphere at its upper end and the tank is gauged in the usual way through the dip pipe as shown diagrammatically in Fig. 8. Care shall be taken to see that the level of any water in the tank is well below the bottom of the dip pipe before gauging, and, if necessary, water shall be drained from the tank. Care shall also be taken not to open the dip pipe cover too suddenly or lower the dip weight too rapidly into the oil, as this tends to set up surging in the dip pipe. If surging is noted, measurements shall not be made until it has ceased. Corrections to the measurements recorded in accordance with the above procedure will have to be made for:

a) the difference between atmospheric pressure and the pressure in the vapour space of the tank, and

b) the difference in density between the oil in the dip pipe and the bulk of oil in the tank.

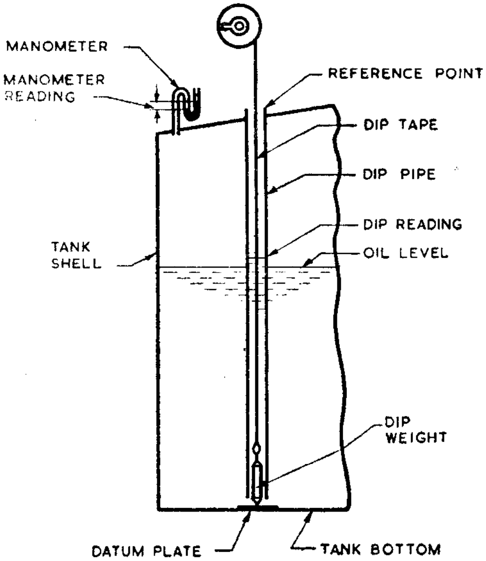

FIG. 8 DIPPING WITH A DIP PIPE AND MANOMETER

13.1.4 *Manometer* — A manometer shall be fitted to the tank for measuring the pressure in the vapour space, in order that the correction may be made for pressure difference. The density of the liquid in the manometer shall be known, and the reading on the manometer shall be recorded by the gauger when the dips are taken. The correction shall be calculated as follows:

a) When the tank is at a higher pressure than atmospheric, subtract from the observed dip reading the product of the manometer reading and the density of the manometer liquid divided by the density of the liquid in the tank, that is

$$H = H_0 - \frac{h_m d_m}{d_0}$$

where

H = the corrected liquid dip,

H_0 = the observed liquid dip,

h_m = the observed manometer reading,

d_m = the density of manometer fluid at the time of observation, and

d_0 = the density of oil in the tank at the time of the observation.

b) When the liquid in the tank is at a pressure below atmospheric, add to the observed dip reading the product of the manometer reading and the density of the manometer liquid divided by the density of the oil in the tank, that is

$$H = H_0 + \frac{h_m d_m}{d_0}$$

NOTE — It is important that the manometer shall be shielded, from the direct rays of the sun to minimize change of density of the manometeric liquid through change in temperature.

13.2 Small differences in density are likely to occur frequently between the liquid in the dip pipe and the liquid in the tank, in particular immediately after a quantity of oil has been received into the tank. The correction for this difference in density is difficult to apply since it is almost impossible to determine accurately the mean density of the liquid in the dip pipe. Trouble with persistent surging may also occur. For these reasons, dip pipes are not recommended for tanks on which official measurements are frequently required. If official measurements are required on a tank fitted with a dip pipe, it is recommended that gauging be carried out when the tank is at atmospheric pressure (as indicated by the manometer), when the tank may be dipped in the normal way through an open dip hatch. Such a condition frequently occurs in the early morning or late evening.

14. PRESSURE TYPE SHORE TANKS

14.1 Spheriodal Pressure Type Tanks — The contents of tanks of this type may be measured by suitably installed gauge glasses, a gauge column, or a suitable gas-lock apparatus.

14.1.1 Both noded and plain type spheriodal tanks deform slightly in shape during filling and emptying as a result of changes of pressure and weight of the liquid. The slight deformation does not materially affect the actual volumetric contents of the tank as the walls of the tank are rigidly braced. When, however, gauge glasses are fitted, care shall be taken during installation to allow for slight local deformation and to provide the glasses with a scale or scales, capable of subsequent adjustment, if necessary.

14.1.2 When a gas-lock apparatus is fitted, it shall be installed directly above a datum plate and preferably near the centre of the tank. The datum plate shall be horizontal metal plate rigidly supported at the bottom of the tank at zero capacity level, or at a known distance from the level. The tank may be either dipped or ullaged by the aid of this apparatus, using a similar procedure to that described in **13.1.1**. If the gauging device does not contain a compensating reference point, the height of the reference point above the datum plate shall be determined each time the ullage method is used. When ullages are taken for official purposes, it is recommended that the gauging height should be checked whenever practicable.

NOTE — It should be appreciated that two main types of gas-lock apparatus are available, one constructed for low pressure storage and the other for high pressure storage. The use of either type is permissible for the gauging of low vapour pressure products contained in spheriodal pressure type tanks, but for the gauging of products which are liquefied under pressure, only the high pressure type shall be used.

14.2 Spherical Pressure Type Tanks — Spherical tanks are usually so rigidly constructed that no sagging or distortion of the shell occurs. When such tanks are in use, changes in pressure due to variation in hydrostatic heat are usually small in relation to the vapour pressure of the liquid stored in them and, therefore, the chief problems in their gauging result more from the nature of the contents than from any deformation of the tank.

14.2.1 Due to the high working pressure in spherical tanks at the highly volatile nature of the products stored in them, measurement by suitably installed gauge glasses or a suitably designed automatic tanks gauge is recommended.

14.3 Horizontal Cylindrical Pressure Tanks — These tanks are rigidly constructed for the storage of highly volatile liquids or liquefied petroleum gases and may be fitted with an automatic gauge or with gauge glasses. Measurements by a gauge column or gas-lock apparatus is permitted as an alternative method, but either apparatus shall be properly designed for the pressures with which it is to be used. Such tanks can also be gauged by mean of slip tubes or roto gauges (*see* **16.2.1**).

14.3.1 Tanks containing liquefied petroleum gases are usually fitted with pressure gauges also, since a knowledge of the pressure in the tanks is required to enable the liquid equivalent of the vapour in the tank to be calculated. Although the liquid equivalent of vapour is relatively a smaller percentage of the total quantity, it is important that the gauger shall record the reading of the pressure gauge. This procedure would ensure the desired accuracy for gauging of LPG.

14.3.2 *Automatic Tank Gauges (Float Gauges)* — Mechanical automatic tank gauges (float gauges) shall be engineered and designed for specific storage vessels. To ensure accurate gauging, the float gauge device shall be properly installed, periodically checked and maintained in good condition. When installing the equipment, the float and guide wires shall be located in such a position that they will be least affected by severe agitation, if any of the tank contents. On pressure vessels, it is recommended that a block valve be installed between the tape drum housing and the tank roof, so that the gauge assembly can be removed for repairs or replacement without taking the tank out of service.

15. BARGE AND SHIP'S TANKS

15.1 Barge Tanks — Barge tanks may be gauged by dipping or ullaging as described in **4** or **5**. Measurements shall be taken from the specified positions which may be ascertained from the barge personnel or by reference to the calibration tables.

15.1.1 When large manholes are used for gauging, it is recommended that they be marked with fixed reference points in order that measurements shall always be taken from the same position. When such marks are not provided, the gauger shall indicate in his notes the positions used for gauging when recording the measurements obtained. If it is necessary to gauge barges after loading viscous liquids while the liquid is still in an aerated condition, the recorded measurements shall be endorsed accordingly. Similarly dips or ullages taken under adverse weather conditions which may render the measurements unreliable, shall be so endorsed.

15.1.2 Accurate measurement will be difficult if the barge is rolling or pitching, thereby causing noticeable swirl or movement of the liquid surface. If gauging is necessary in such circumstances, errors may be minimized by carefully watching the movement of the vessel and timing the measurements so that they are taken during the brief interval of time when the liquid surface is passing through its normal position. At least four consecutive readings shall be taken and recorded for each tank, and the gauger shall indicate in his notes the conditions under which the measurements were taken. The effect of small ripples and the movements on the surface may be minimized by the use of a damping device. This device, which is illustrated in Fig. 9, consists of a length of glass tubing encasing that portion of the dip tape on which the measurement will be indicated. The tube is attached to the tape by means of split corks inserted in each end of the glass tube on each side of the tape. Holes through both upper and lower corks allow the liquid to enter the tube and to attain a static level in equilibrium with the mean level of the surrounding liquid while the glass tube prevents the ripple from coming in contact with the tape.

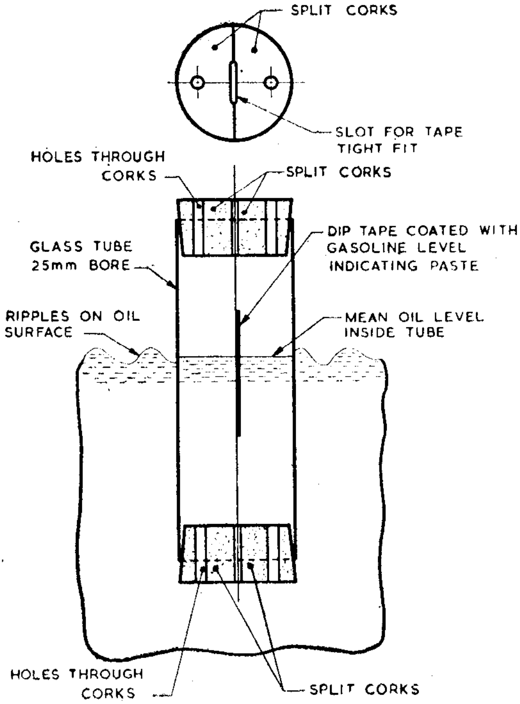

FIG. 9 RIPPLE DAMPING DEVICE

15.1.3 A barge tank capacity table is calculated to be correct when the barge is on an even keel. When the barge is listed, or is trimmed by the head of stern, errors in measurement will occur:

a) because the tank is not then gauged in the plane normal to the even keel water line, and

b) if the tank is gauged in a position which does not correspond to its geometric centre.

Barge tanks are frequently fitted with a dip pipe installed perpendicular to the even keel water line in order to overcome the error due to (a). Such a dip pipe shall be adequately perforated throughout its length. When a barge is not fitted with centrally arranged dip hatches, errors due to (b) are frequently overcome by arranging the dip hatches on adjacent tanks symmetrically above transverse or longitudinal bulkheads, when, if the tanks are filled to approximately the same level, errors in adjacent pairs of tanks tend to cancel out.

15.1.4 When measurements for official purposes are required on a barge which is not fitted with dip pipes and centrally or symmetrically placed dip hatches, the trim or list shall be determined to enable the necessary correction to be applied. The trim may be obtained by observing the draught scales on the stem and stern posts, and the list by measuring the free board on either side of the barge by ullage from the gunwale. These figures may alternatively be ascertained from the barge personnel. The trim and list so obtained shall be reported in the gauger's note together with other relevant information. The correction for trim and list shall be calculated by accepted mathematical principles from the known dimensions of the barge and tanks, and the positions of the hatches. As, however, the calculation is tedious and liable to error, it is recommended that barges on which official measurements are required to be brought to approximately an even keel whenever this is practicable. Official gauge measurements shall not be taken on any tank if the oil level is in contact with the deck head or is above the maximum calibrated depth.

15.2 Ship's Tanks — Ship's tanks may be ullaged or dipped, according to circumstances. Tank capacity tables for most ships are compiled on an ullage basis and as ship's tanks contain various obstructions and frequently have sloping bottoms which may lead to inaccuracies in dipping, it is strongly recommended that gauging be done by ullage except for measuring water, or when the tanks contain only small quantities of oil.

15.2.1 Before gauging commences, the correct positions from which ullages are to be taken shall be ascertained from the ship's officers. Ship's tanks are frequently calibrated with reference to a fixed datum point marked on the edge of the hatch coaming and it may be necessary to gauge such tanks with the tank lid closed. Ullage-plugs are provided in the tank lids for this purpose. Ullages shall be taken in the usual way, but the vertical distance between the edge of the ullage-plug and the fixed reference point shall be subtracted from the observed ullage reading. This distance may be measured directly, or indirectly by taking the difference between the height of the ullage-plug and the height of the fixed reference point above the tank bottom, or it may be obtained from the ship's officers. In the latter case, care shall be taken to allow for any change in the thickness of the tank lid gasket by variations in its compression. In other vessels, separate ullage pipes may be fitted and measurements shall be taken from these in the usual way. However, care shall be taken to see that ullages are measured from the correct reference point on the pipe and that the thickness of the plug washer is not included in the measurement.

15.2.2 Water in ship's tanks shall be measured by water-finding rule, care being taken to ensure that the rule does not come to rest on any obstruction in the tank. To check that the water dip has been measured at the correct depth, the overall depth shall be measured and compared with the figure given in the tank capacity table.

15.2.3 Attention is drawn to **15.1** in connection with errors due to trim and list. When ship's measurements are required for referee purposes, correction for trim and list shall be made, if required.

16. RAIL OR ROAD TANKS

16.1 Conventional Containers — These containers may be gauged by dip or ullage, a dip rod or ullage stick usually being employed. Alternatively the quantity of liquid in the containers may be measured by direct weighing.

16.1.1 The vehicle shall be standing on level ground with the contents at rest during gauging and any water which may be present shall be removed before gauging commences.

16.1.2 When a weigh-bridge is available, the weight of liquid in a tank-vehicle may be determined by taking the difference between the total weights before and after filling or emptying. When weighing vehicles, personnel shall not be in or on the vehicle, and in the case of road vehicles, the engine shall not be running whilst weighing is in progress. If the gross and net weights are determined at the beginning and end of a journey respectively, any change in the quantity of fuel in the fuel tank of the vehicles shall be taken into account in calculating the net quantity of the load, and the vehicles shall otherwise be in the same condition. When the contents of tank-vehicles are measured by weighing, it is recommended that dip or ullage measurements may also be taken and recorded.

16.1.3 The corresponding volume at standard temperature or at the temperature of measurement, if required, shall be calculated from the net weight and the specific gravity (or density) of the liquid at the required temperature (*see* IS : 2164-1961*).

16.2 Pressure Type Containers — High pressure containers used for transporting liquefied petroleum gases are sometimes fitted with special gauging devices, such as the ' slip tube gauges ', but measurement by weighing is to be preferred whenever it is possible.

16.2.1 *Gauging by the Slip Tube*

16.2.1.1 *Slip tube gauge* — The slip tube gauge (*see* Fig. 10) consists of a tube 6 mm to 12 mm in diameter, with a valve at the upper end. The tube extends through a packing gland in the shell plate. It can be secured by a lock or catch in the down position and is graduated to at least five-millimetre divisions which should be accurate to at least one millimetre with respect to the fixed pointer. The scale may be either for dip or ullage measurements, depending on whether the tank is calibrated for dip or ullage. The reference points should preferably designate the basis to which the scale reads.

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*Method for calculation of bulk quantities of petroleum and liquid petroleum products.

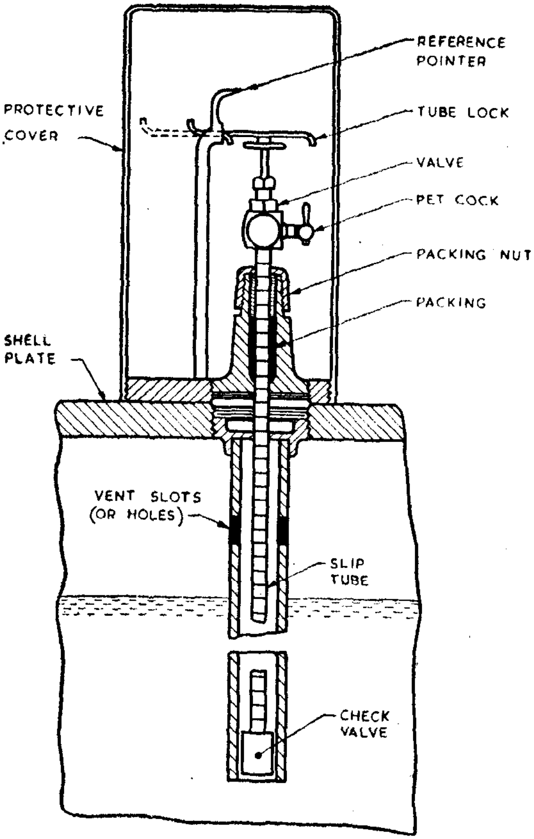

FIG. 10 SLIP TUBE GAUGE

16.2.2 To ensure that there is no surging of product in the container, a minimum settling period of 15 minutes should be allowed after the movement of product into or out of the container, or when the container is mobile (tank trucks, tank wagons, etc) after the container has come to rest. Remove the protecting cover from the 'slip tube gauge' (*see* Fig. 10).

Release the tube lock or brake with one hand while holding the tube firmly with the other to prevent the pressure in the tank from forcing the tube violently upward. Raise the tube to a convenient height and open the valve just enough to permit a slight flow. Raise the tube until vapour only flows from the valve. Excessive flow of vapour will cause inaccurate gauging because liquid will be drawn into the tube by adequate suction before the lower end is actually at the liquid level. Lower the tube *slowly* until both vapour and liquid flow, allowing sufficient time for the liquid to travel the length of the tube. Note and record the reading opposite the tip of the pointer as the dip or ullage, as the case may be. To make sure that the lower end of the tube is at liquid level, raise the tube by 2 to 3 mm to ascertain that only vapour flows from the valve. Repeat the entire procedure until the readings check within 5 mm.

17. PIPE-LINES

17.1 When it is known that a given length of pipe-line is completely full of liquid, the volume of liquid which it contains can readily be calculated from the length and internal diameter of the line.

17.2 It is recommended that the length and internal diameter of all pipe-lines, which may be used in bulk oil measurements, be carefully measured and recorded on a suitable plan which should indicate the length and size of each section of line or, alternatively, the capacity. The position of stop valves should be clearly marked, and the plan should be amended as and when additions or modifications are made.

17.3 When tank measurements are taken, the gauger shall report in his notes the appropriate condition of the line as ‘ full ’, ‘ empty ’ or ‘ unknown ’, as the case my be.

SECTION III REPORTING

18. GAUGING MEASUREMENTS

18.1 When reporting measurements, the gauger shall give all relevant details of date, time, tank designation, points at which measurements have been taken, etc. If any pipe-line connections are open to the tank at the time of gauging, full details shall be reported; and in cases where measurements are taken in connection with transfer of liquid in bulk, the condition of all associated pipe-lines at the commencement and finish of the operation shall be included in the gauger’s report.

18.2 At the time of gauging, the gauger shall also take temperature readings in accordance with the procedure laid down in IS : 1519 (Part I)-1961* and IS : 1519 (Part II)-1964†. These readings shall be included in gauging record. Samples for determination of density and, if necessary, water and sludge contents shall normally be taken by the gauger and the results reported by the laboratory. Such samples shall be taken in accordance with the procedures laid down in IS : 1447-1966‡ and shall be adequately and clearly labelled to ensure that the results reported by the laboratory are used in conjunction with the correct gauging measurements for the determination of oil quantities.

18.3 The measurements recorded by the gauger shall be the actual readings observed and shall be taken to the nearest graduation of the apparatus employed. When the observed reading is between two calibration marks:

a) the lower graduation shall be recorded as the measurement, if the observed readings is less than half the distance between that graduation and the next higher one, and

b) the higher graduation shall be recorded as measurement, if the observed reading is equidistant between the two graduations or nearer to the higher one.

18.4 The use of standard equipment and procedure enables correct measurements of dip to be obtained as direct readings, but in the case of ullage measurement if a correction has to be applied for the distance between the point from which the ullages are taken and the correct reference point, both the observed reading and the correction shall be recorded. When ullage measurements are taken, the height of the fixed reference point above the dipping datum point as marked on the roof should be reported in the gauger's notes.

18.5 Ship's cargo tanks are usually ullaged and, owing to the larger number of compartments which require gauging, the gauger is frequently accompanied by a ship's officer and the measurements taken are recorded jointly, the gauger verifying that each reading has been correctly recorded before proceeding to the next compartment. It is important to record whether ship's tanks are numbered from fore to aft or vice versa, and the port and starboard measurements shall be clearly defined. When a ship's cargo tank is provided with two ullage hatches, measurements at both points shall be taken and recorded but, except when the vessel is listed or trimmed, only those measurements taken at the ullage hatch specified in the tank capacity table shall be taken into consideration when calculating the oil quantities. The list and trim of the ship, if any, shall be recorded.

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*Method for temperature measurement of petroleum and its products, Part I.

†Method for temperature measurement of petroleum and its products, Part II.

‡Methods of sampling of petroleum and its products.

SECTION IV PRECAUTIONS

19. SAFETY PRECAUTIONS

19.0 The following safety precautions constitute good practice, but the list is not necessarily comprehensive. The precautions shall be followed whenever they do not conflict with local or other regulations.

19.1 General Safety Precautions — The following safety precautions apply in all cases:

a) Access ladders, stairways, platforms and handrails shall be maintained in a structurally safe condition;

b) Plant and equipment shall be adequately maintained, and it is recommended that a regular inspection be made by a competent person;

c) Gaugers shall be provided with carriers for their equipment in order that their hands may be free for climbing ladders;

d) All regulations covering entry into hazardous areas shall be rigorously observed;

e) Care shall be taken, when opening dip hatch covers, to stand so that any vapours expelled do not strike the face;

f) Hand lamps and torches lights shall be of an approved type;

g) Footwear capable of causing sparks shall not be worn in areas where inflammable vapours are likely to be present;

h) Clothing apparel, such as nylons, silk, etc, capable of generating and accumulating static electricity shall not be worn;

j) To eliminate hazards from static electricity, care shall be taken to ensure that dip tapes, metallic dip rods, etc, remain in metallic contact with the container at least until a portion is immersed in the liquid;

k) Oil-soaked rags and cotton waste shall not be left lying about but shall be placed in a suitable receptacle; and

m) If non-volatile oil is spilled on the roof of a tank, it shall be cleaned up immediately.

19.2 Special Safety Precautions — The following safety precautions are necessary, in addition, when dealing with particular equipment or products.

19.2.1 *Leaded Fuels* — The standard precautions regarding the handling of leaded fuels shall be meticulously observed.

19.2.2 *Liquefied Petroleum Gases* — Liquefied petroleum gases can cause serious cold burns. Care shall be taken, therefore, to prevent the liquid product from coming into contact with the skin.

19.2.3 *Pressure Type Storage* — All gauging equipment used on pressure type storage shall be designed to withstand a pressure equal to the working pressure plus an adequate safety factor.

19.2.4 *Floating-Roof Tanks* — Floating roof tanks should be sampled from the top platform whenever practicable, as under certain conditions toxic and inflammable vapours may accumulate above the roof. When it is necessary to descend to the roof for sampling, and if any of the following conditions persist the operator shall wear breathing apparatus unless the atmosphere above the roof has first been proved to be safe:

a) When the product contained in the tank is sour,

b) When the roof is at rest on its supports or is partly immersed,

c) When the roof-seal is known to be faulty, and

d) In any other circumstances when there may be vapours present in dangerous concentrations.

19.3 General Recommendations

19.3.1 It is strongly recommended that gaugers be thoroughly trained in gas-safety including the uses and limitations of rescue equipment.

19.3.2 It is recommended that trays or other containers be provided near dip hatches on the roofs of tanks containing non-volatile products to hold gauging equipment after it has been used, and so to prevent unnecessary spillage on the roof.

20. GENERAL PRECAUTIONS

20.0 The following general precautions shall be observed on equipment, apparatus and procedure.

20.1 Equipment

20.1.1 A dip hatch or other opening used for dipping or ullaging shall be provided with a reference point so situated that when the dip weight, water-finding rule, sampling device or other apparatus is lowered through the hatch, it will touch the datum point on the tank bottom, and will not foul heating coils or other obstructions within the container. To ensure accuracy in measuring ullage when the dip hatch is liable to movement owing to flexibility of the roof plates to which it is attached, the reference point shall be marked on a rigid attachment securely fixed to the vertical shell of the tank. In all cases, the height of the reference point above the datum point on the tank bottom shall be clearly marked near the hatch and this height shall be verified periodically.

20.1.2 When a container is provided with more than one dip hatch, each hatch shall have a number, or other means of identification, clearly marked on, or near it. In addition, the dip hatch for which the tank capacity table is computed shall be clearly identifiable and this hatch only shall be used for dipping or ullaging except as described in **11.1.1**.

20.1.3 Dip hatches of conventional containers shall allow direct access to the bulk of liquid in the container. Dip pipes shall not be used in tanks which are gauged at atmospheric pressure except when pipes of satisfactory perforated design are used to improve accuracy of measurement as described in **15.1**.

20.1.4 Dip pipes installed in vapour-tight tanks shall be of ample cross-sectional area in relation to that of the standard dip weight.

20.1.5 Existing vapour-tight or pressure tankage may already be fitted with gauge glasses, but, where it desired to fit gauge glasses to new tankage of this type, it is strongly recommended that such gauge glasses be construced and installed as laid down in **6.2.1**. Gauge-glass scale shall be strongly and accurately constructed and securely fitted closely alongside the gauge glasses. The scales shall be provided with seals to prevent unauthorized movement of the scale relative to the container. Gauge glasses and their connections shall be shielded from the sun's rays and should preferably be situated on the side of the container least exposed to the sun.

20.1.6 Gauge glasses and their accessories shall be carefully maintained and kept in clean and sound conditions.

20.1.7 The internal bulkhead or bulkheads of multi-compartment tanks shall be sufficiently rigid to prevent deformation when adjacent compartments contain oil at different levels.

20.1.8 Weigh-bridges shall be officially calibrated and checked at frequent intervals. They shall be kept free from accumulations of water, dust and other material which might affect their accuracy.

20.2 Apparatus

20.2.1 All apparatus used for gauging shall conform to standards laid down in Appendix A (*see also* **0.3**) and shall be checked periodically to ensure conformity with these standards. Particular attention shall be paid to the relation between dip tape and dip weight, ullage rule and water-finding rule, to ensure that their graduations are in the correct system of units.

20.2.2 Dip tapes shall be free from kniks, rust, etc, and the markings on all graduation apparatus shall be legible.

20.2.3 Dip rods are liable to wear at the tip and when they are calibrated directly in units of volume, the datum mark shall be scribed on each rod when new, in order that the zero marking may be periodically checked for accuracy.

20.2.4 All dip rods or ullage sticks which are used for a specific tank or tanks, and this shall apply to any dip rod or ullage stick calibrated in units of volume shall be permanently and clearly marked with the same identification mark or marks as the tank or tanks with which they are used. They shall not be used for any other tank.

20.2.5 As far as practicable, apparatus should be made of non-sparking material.

20.3 Procedure

20.3.1 Official measurements shall be taken by, or under the immediate supervision of a person of skill and experience in gauging.

20.3.2 When a container is equipped with more than one gauge hatch, the hatch to be used shall be stipulated. Measurements before and after each bulk movement of liquid shall be taken by the same method and at the same position. Water measurements shall be taken at the same position or positions as those used for the corresponding liquid measurement.

20.3.3 Measurements shall be made in duplicate and recorded immediately after they have been taken. The recorded measurements shall be agreed to by all interested parties before they leave the tank.

20.3.4 Before measuring for official purposes, the conditions of any pipelines involved in the measurement shall be checked and reported. Precautions shall be taken to ensure that oil or water does not flow into or out of the container during measurement. In the case of shore tanks, all inlet and outlet connections shall be closed when gauging for stock accounting, but before gauging shore tanks from which deliveries are to be made, the tank valves shall be open to the line. If two or more tanks are to be used on the same line for one grade of product, only the valves on the tank being gauged shall be opened to the line when the movement is completed; and all tank valves shall be closed before final measurements are taken. When gauging ship's tanks before discharge of cargo, all suction and other valves which might permit gravitation from one compartment to another shall remain closed until all gauging is completed.

20.3.5 After liquid has been pumped to or from a tank, gauging shall not be commenced until time has been allowed for the cessation of any movement of the liquid surface and for settlement of water and sediment. In the case of viscous liquid, time shall be allowed for any entrained air to be liberated from the liquid. When foam is present on the surface of the oil, it shall be allowed to subside or be cleared from the surface beneath the dip hatch before measuring the oil depth. Where accurate measurements are required, a minimum settling time of 4 hours shall be given in case of receipt of product in the tank and ½ hour in case of withdrawal of the product.

20.3.6 The number of persons present on the roof during gauging shall be same both before and after a movement of oil.

APPENDIX A

(*Clauses* 0.4, 4.1, 4.2, 5.1, 5.3, 9.1 *and* 20.2.1)

SPECIFICATIONS OF APPARATUS

A-1. SPECIFICATIONS

A-1.0 In order that measurements shall be consistently of the required accuracy, some of the requirements (*see* **0.3**) of apparatus used for gauging of petroleum and petroleum products are as follows and are for general guidance.

A-1.1 Dip Tapes — conforming to **5** of IS : 3515-1966*.

A-1.2 Dip Weights — conforming to **6** of IS : 3515-1966*.

A-1.3 Dip Rod

A-1.3.1 The dip rod (*see* Fig. 11) to be used shall consist of a metal (preferably non-sparking) rod. It shall be sufficiently rigid to ensure that it does not distort in use.

A-1.3.2 Dip rods for measuring dip or ullage of small tanks and containers shall conform to the following specifications:

a) *Material* — brass or other suitable non-sparking metal. The material should not be so ductile that it bends under its own weight.

b) *Construction* — Dip rods shall be of square section. The top end shall be suitably finished to either:

  1) fit into the dip cap of the tank on which it is being used, or

  2) have a holding ring.

The bottom of the dip rod shall be made of a separate piece tapered at its lower end. This piece shall be riveted on to the rod by two brass or copper rivets.

c) *Dimensions*

  1) Rod

  Length : To suit the tank or container on which the rod is being used, but it shall not be more than 4 m

  Cross section 13 mm square

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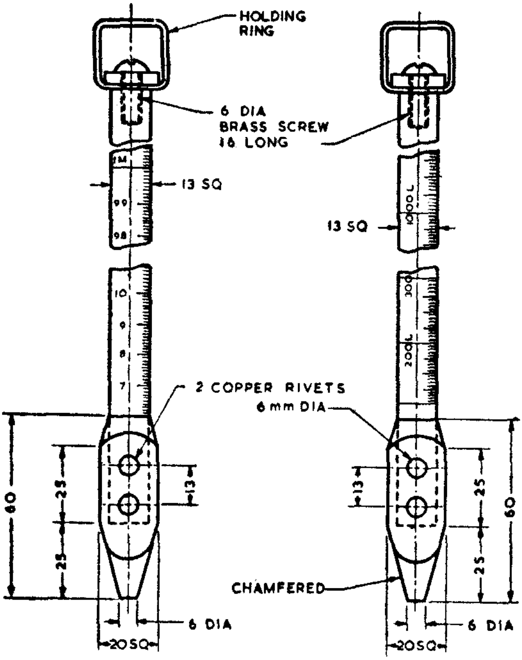
*Specification for tapes for use in measurement of oil quantities.

2) *Bottom piece*

Length, overall	60 mm
Length of lower tapered end	25 mm
Cross section	20 mm square
Diameter at bottom end	6 mm
Diameter of rivets	6 mm

d) *Scale* — The rod shall be marked on one side only. It may be graduated in metres, centimetres or millimetres, or in kilolitres and litres, as desired by the purchaser.

NOTE — When it is marked in litres, the rod shall be suitable for only that tank on which it is calibrated. Dip rod should also indicate the corresponding height pertaining to the volume in mm. The dimensions of the tank for which the dip is calibrated shall, therefore, be stamped on one of the blank faces. The accuracy of 2 mm is recommended.

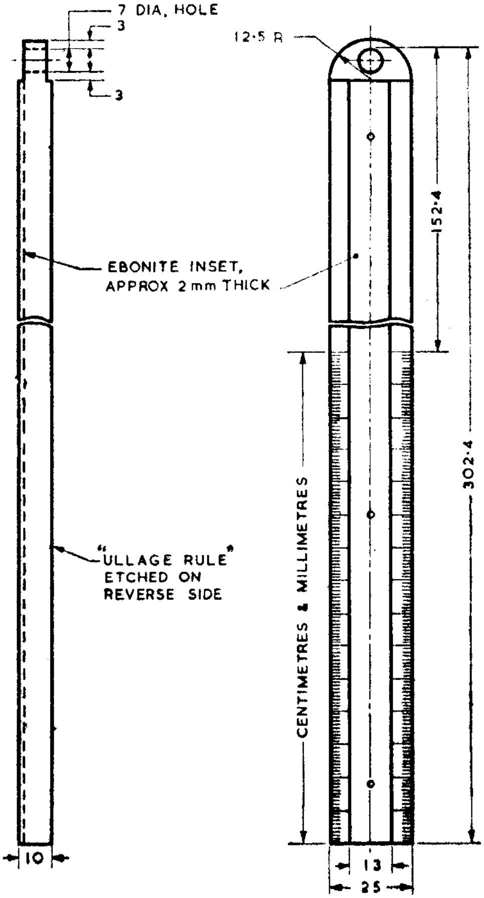


11A Graduated in cm and mm   11B Graduated in litres

FIG. 11 DIP ROD

A-1.4 Ullage Rule

A-1.4.1 The ullage rule (*see* Fig. 12) to be used within the dip of tape shall be provided with a hole which engages the swivel hook of the dip tape. It shall be fitted with an ebonite inset throughout its length and shall be graduated on one side only, downwards from a zero point. The distance of the zero point from the top cf the hole shall be fixed precisely.



All dimensions in millimetres.

FIG. 12 ULLAGE RULE

A-1.4.2 Ullage rule for use with the standard dip tapes shall conform to the following specifications:

a) *Material* — brass or other non-sparking material sufficiently hard to resist damage by contact with steel. The front face shall be fitted with an ebonite inset 13 mm wide, throughout its length.

b) *Construction* — The top of the rule shall have an integral lug or tongue with a horizontal hole 7 mm in diameter for engaging the swivel hook of the dip tape.

c) *Dimensions*

Length	Not less than 30·24 cm from base to top inside edge of hole where the swivel connection is made
Width	25 mm
Thickness	10 mm. The thickness of the eyes lug to be 7 mm.

d) *Weight* — about 800 g.

e) *Scale* — Graduated in centimetres and millimetres, on the side having ebonite inset, downwards from a zero precisely 15·24 cm below the top of the hole. The upper 15·24 cm of the rule shall not be graduated.

A-1.5 Ullage Stick (Ullage Rod)

A-1.5.1 The ullage stick shall consist of a graduated rod, to the upper end of which a cross-piece shall be securely fixed at a right angle to its major axis. The ullage stick shall preferably be made of non-sparking metal, but wood is permitted. If wood is used, it shall be maple or similar wood, dyed with aniline black and rubbed down to a smooth polish. In all cases, the rod shall be of such dimensions that it will not distort in use, and it shall be graduated downwards from a zero level with the underside of the cross-piece. The cross-piece shall be long enough to rest across the ullage hatch on which the ullage stick is to be used.

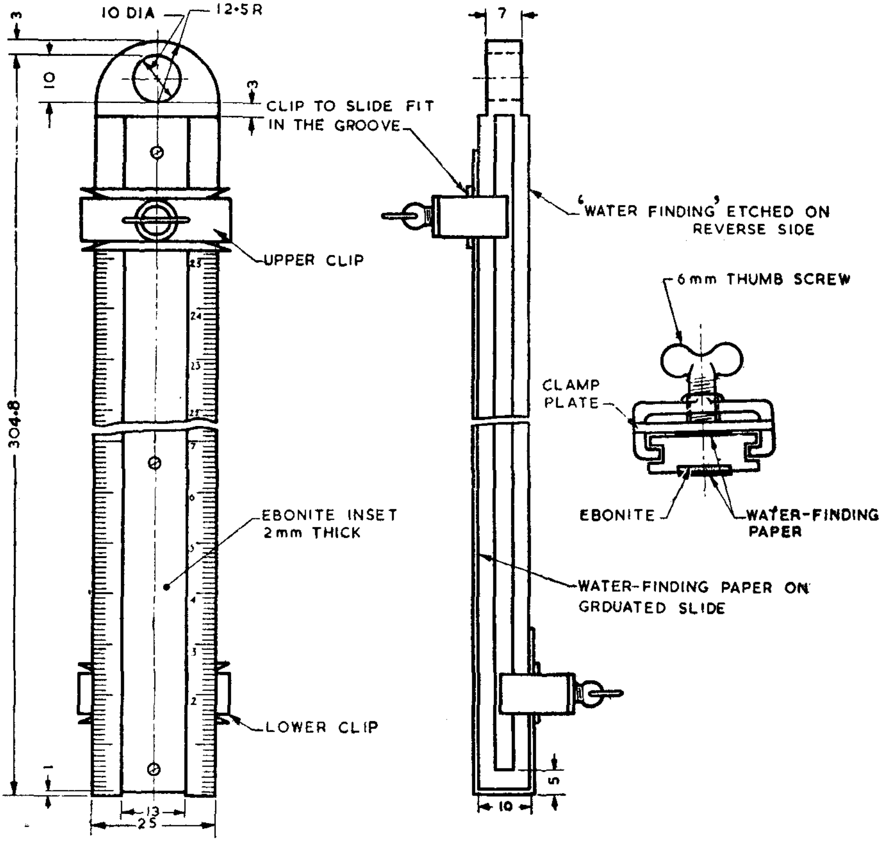
A-1.6 Water-Finding Rule

A-1.6.1 The water-finding rule (*see* Fig. 13) shall be used in conjunction with water-indicating paste or paper for measuring depths of water. The rule shall be provided with clips for holding the water-finding paper in position, as shown in the illustration.

A-1.6.2 Water-finding rules shall conform to the following specifications:

a) *Material* — brass or other non-sparking material, sufficiently hard to resist damage by contact with steel.

b) *Construction* — The bottom of the rule shall be cut square and shall be provided with a recess thirteen millimetres wide and one millimetre deep. All sides, edges and particularly the bottom shall be made smooth. Clips shall be provided for holding the water-finding paper in position, and the edges of the rule shall be grooved to receive the clips, the grooves being stopped 5 mm from the bottom. The top of the rule shall have an integral tongue in which a hole of 10-mm diameter shall be drilled centrally to permit attachment to either the standard dip tape or to a cord. A strip of ebonite 13 mm wide shall be inset for the full length of the rule on one face.



All dimensions in millimetres.

FIG. 13 WATER-FINDING RULE

c) *Dimensions*

Length	304·8 mm from base to top inside edge of the hole
Width	25 mm
Thickness	10 mm

d) *Weight* — not less than 550 g.

e) *Scale* — graduated in centimetres and millimetres on the face bearing the ebonite inset upwards from the bottom of the rule.

INDIAN STANDARDS
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PETROLEUM MEASUREMENTS

IS:	
1518-1980	Method for gauging of petroleum and liquid petroleum products (*first revision*)
1519 (Part I)-1961	Method for temperature measurement of petroleum and its products, Part I
1519 (Part II)-1964	Method for temperature measurement of petroleum and its products, Part II
2007-1974	Method for calibration of vertical oil storage tanks
2008-1961	Method for computation of capacity tables of vertical oil storage tanks
2009-1975	Method of calibration of horizontal and tilted oil storage tanks (*first revision*)
2164-1961	Method for calculation of bulk quantities of petroleum and liquid petroleum products
2166-1963	Method for computation of capacity tables for horizontal and tilted oil storage tanks
2808-1964	Method for computation of capacity tables for pressurized storage tanks
2827-1976	Methods for calibration of pressurized storage tanks (*first revision*)
8818-1977	Methods for measurement of petroleum gases and town gas in bulk

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